Where is the tip? -Misplaced tubes and lines on a Paediatric Chest Radiograph.

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Learning objectives

(1) Understand the importance of chest radiograph evaluation of commonly used invasive support devices in critically ill children;

(2) Review normal positions of various support devices;

(3) Identify how to recognise misplaced devices and associated complications.
Background

Interpreting chest radiographs of critically ill children is a challenge for radiologists and physicians. All lines and tubing should be identified on a chest radiograph prior to assessing important review areas. The initial portable chest radiograph plays an essential role in recognising correct placement and complications. Rapid interpretation of imaging is required often with inadequate clinical information, changing clinical parameters, artefact from overlying material, for example, lying on a trauma board, foam mattresses or other similar support.

A pictorial review of the normal position of the different lines and tubes is given, with an emphasis on relevant anatomy. We will look at how the technical quality of the film and patient positioning can affect visualisation of support devices. We highlight important features of incorrect placement of endotracheal tubes, thoracostomy tubes, enteric feeding tubes and paediatric vascular lines (peripherally inserted central catheters and umbilical arterial/ venous catheters).
Findings and procedure details

Endotracheal intubation

Endotracheal (ET) intubation is the most common procedure in neonates. The trachea is shorter in children compared to adults and the optimal position of the tip should be around 1.5 cm above the carina (Fig 1). If the carina is not visualised due to technical factors, the ideal position of the ET tube is in the middle third of the trachea at the level of the 2nd - 4th thoracic vertebral body level, with the neck in neutral position. Flexion or extension of the neck may cause the ET tube to move position. Neck flexion causes displacement of the ET tube tip toward the carina. In children, head rotation to either side often results in withdrawal of the ET tube away from the carina. It is not uncommon to inadvertently intubate the oesophagus. The oesophagus is usually projected over the tracheal air column, although if gas is seen outlining the oesophagus and it is distended, this complication should be suspected (Fig 2).

Nasogastric Tube

A nasogastric tube should be located to the left side of the spine and the tip should be seen in the stomach in the left upper quadrant (Fig 3). Iatrogenic oesophageal perforation occurs mainly in preterm and low birth weight babies secondary to difficult intubation and forceful attempts to pass nasogastric tubes and suction catheters. The perforation usually occurs in the cervical oesophagus, most commonly involving the pyriform sinus (Fig 4). Abnormal positioning of a nasogastric tube can also be related to underlying pathology, for example, a congenital diaphragmatic hernia (Fig 5).

Nasojejunal tube

Nasojejunal feeding is used for patients at greatest risk of aspiration pneumonia, patients intolerant of gastric feeding, patients with recurrent emesis or severe reflux and patients who have undergone major surgery or sustained severe trauma. The tip of the nasojejunal tube should be in the jejunum, beyond the ligament of Treitz. Proximal placement of the nasojejunal tube in the duodenum is avoided by fluoroscopic placement (Fig 6).

Oesophageal pH monitoring

Oesophageal pH monitoring is the current gold standard for diagnosis of gastro-oesophageal reflux. In the assessment of gastroesophageal reflux, correct placement of
the pH catheter is crucial, particularly in very low birth weight infants where a small error in positioning could give rise to a potentially large error in result. The normal position of the pH probes should be above the gastro-oesophageal junction and at our institution, we prefer the sensor for the probe to be positioned at the level of T8 to T10 (Fig 7 and Fig 8).

**Umbilical venous catheter**

An umbilical venous catheter passes through the umbilicus, umbilical vein, left portal vein, ductus venosus, middle or left hepatic vein and then into the inferior vena cava. The tip should lie at the junction of the inferior vena cava and the right atrium, around the level of T8 - T9. Placement of the catheter tip in the portal circulation is not acceptable in our institution. If this position is not achievable, the umbilical venous catheter (UVC) tip must lie completely below the liver.

Malposition of umbilical venous catheter occurs if the UVC is:

(a) *too short* with the tip in a low position in the umbilical vein which may prevent the administration of certain medications.

(b) *too long* with the tip seen in the right atrium or in the left atrium through a patent foramen ovale or atrial septal defect and this can lead to cardiac arrhythmias/ perforation (Fig 9).

(c) *wrong turn* when the UVC enters the left portal vein but does not continue into the ductus venosus. The catheter can extend into the more peripheral left portal vein or it can enter the right portal vein or it can travel hepatofugally into the main portal vein or into the superior mesenteric or splenic vein. This can lead to thrombosis or perforation of the portal vein with subsequent haemorrhage or liver abscess formation.

**Umbilical arterial catheter**

An umbilical arterial catheter (UAC) passes through the umbilicus and then extends inferiorly through the umbilical artery into the common iliac artery and then into the aorta (Fig 10). The UAC is in a high position if the tip at the level of descending thoracic aorta (T6-T10). The UAC is in a low position if the tip is seen below the level of L3. The coeliac and renal arteries originate at T12 and SMA originates at L1. The UAC tip should not be seen between T10 - L3.

**Central Venous Lines**
Peripherally Inserted Central Catheter (PICC) lines are inserted in a peripheral vein in the arm, such as the cephalic vein, basilic vein or brachial vein, and then advanced proximally toward the heart through increasingly larger veins, until the tip is located at the cavoatrial junction. Peripherally inserted central lines are made of silicone or polyurethane and are used with a two piece catheter joined by a hub, the peelable needle or cannula, and narrower gauge catheters. Central lines can inserted over a guide wire and these are usually placed at the puncture site of one of the neck veins or the femoral vein. Surgically inserted central lines are inserted after direct cut down which is usually done using a Hickman or Broviac catheter into a jugular vein.

It is important to assess for a high position (Fig 11), low position, coiling (Fig 12) or line fracture (Fig 13). Note should be made that a chest radiograph gives a 2D image to illustrate the complex 3D structure of the heart and great vessels. Contrast injection may under- or overestimate catheter length, because the catheter may be either partially filled or extrude a jet of contrast from the tip at the time of the examination.

Thoracostomy tubes

Tube thoracostomy is widely used throughout the medical, surgical, and critical care specialities. Complications resulting from tube thoracostomy can occasionally be life threatening. Tube malposition is the commonest complication of tube thoracostomy. This can be intraparenchymal tube placement, fissural tube placement, chest wall tube placement, mediastinal tube placement and abdominal tube placement. The exact position of the tube may be difficult to ascertain on an AP view, and a lateral view may be required if there is concern regarding malposition (Fig 14).
Fig. 1: The chest radiograph shows that the tip of the ET tube is too high, above the thoracic inlet with resultant atelectasis (white arrowhead). Incidental note is made of multiple segmentation abnormalities in the thoracic and lumbar spine.

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Fig. 2: If the ET tube deviates away from tracheal air shadow and the oesophagus is dilated, suspect an oesophageal intubation. The oesophagus has been outlined in white in the image.

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Fig. 3: Incorrect position of the NG tube with the tubing seen to the right of the thoracic spine and the tip is seen in the right upper quadrant (white arrow).

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Fig. 4: A contrast study obtained using fluoroscopy shows the correctly positioned nasogastric tube, seen to left side of the spine and stomach filled with contrast (white arrowhead). The incorrectly positioned feeding tube is seen to the right of the thoracic spine (white arrow) with the right pleural cavity delineated by the contrast. The perforation occurred at the level of the right pyriform sinus.

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Fig. 5: Fig. 5: Indistinct left hemidiaphragm with opacification of the left hemithorax. The nasogastric tube is coiled in the left thoracic cavity (white arrow) in a previously undiagnosed left congenital diaphragmatic hernia.

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Fig. 6: Fig. 6: The nasogastric tube (white arrowhead) is looped into the nasojugal tube (white arrow) which is proximally sited at the junction of the 2nd and 3rd part of the duodenum. These were then correctly sited using fluoroscopic guidance.

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Fig. 7: The sensor for the pH probe (white arrow) is low lying in the stomach.

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Fig. 8: The pH probe (white arrow) is coiled in the proximal oesophagus and the sensor is seen at the thoracic inlet.

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**Fig. 9:** The UVC is in a high position with the tip (white arrow) at junction of superior vena cava and right atrium.

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Fig. 10: The coil (white arrowhead) is external to the patient and is not the typical loop from the umbilicus inferiorly to the internal iliac artery, which is seen with an umbilical arterial catheter. This is an umbilical venous catheter looped external to the patient and should not be confused with an umbilical arterial catheter. An umbilical venous catheter predominantly follows an anterior and cephalad course in the midline umbilical vein until directed posteriorly in the liver, whereas the umbilical artery catheter is initially directed caudally and posteriorly to enter either the right or left iliac artery.

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Fig. 11: The tip of the right subclavian line (white arrow) is seen in a high position, crossing the midline, on this projection on which the patient is rotated.

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Fig. 12: The femoral long line is looped with the distal tip seen inferiorly (white arrow); femoral long line after repositioning with the tip in the correct place (arrowhead). The tip of the long line should lie either in the inferior vena cava downstream from the level of the renal vein, or above the diaphragm in the right atrium. Note artefact from the underlying mattress.

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Fig. 13: Fractured PICC line (white arrow) with the tip in the pulmonary conus (white circle).

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**Fig. 14:** The tip of the chest drains is delineated by the white arrows; The exact position is difficult to assess on the AP view. The lateral view clearly demonstrates that the tube is orientated posteriorly (white arrowhead) whereas the pneumothorax lies anteriorly (*).
Conclusion

Serious complications arising from the insertion of medical support devices and use are often not clinically apparent. Evaluation of invasive support devices used in critically ill children on chest radiography is important, because potentially serious complications arising from their insertion and use are often not clinically apparent.
References

